A fluid separation device

The present invention relates to a fluid-separating device, for separating fluid and/or fluid spray from a gas. Such separators are for example applied for separating oil or oil spray from blow-by gases (crank housing gases, blow-through gases) of combustion engines. A further scope of application for fluid separators lays in the field of electrochemical cells, in particular PEM fuel cells, in particular those which operate in a temperature range suitable for H_2O, in particular between 20°C and 160°C.

Such fuel cells typically have powers between a few watts and several kilowatts. Such PEM fuel cells (polymer electrolyte membrane fuel cells) have a polymer membrane permeable to protons. This membrane needs to have a certain moisture content in order not to dry out and thus not to lose its functioning ability on account of this. For this reason, the supplied reaction gases are previously humidified. For this, according to the state of the art, treated water in a humidifier is used for the corresponding supplied reaction gases on the anode and cathode side. On the other hand, on the cathode side of the fuel cells pure water arises as a reaction product so that here on the exit side an enormous water excess is present in the gases which are led away, which condense directly after leaving the fuel cell. In order to separate this water from the gases which are led away, one likewise applies fluid separation devices in order to lead back this water for humidifying.

According to the state of the art, common labyrinths or metal knitted fabrics or in particular cyclones are used for separating fluid.

For separating dust particles from gases, tubular separators are known which comprise a flow-through tube through which the gas is led. Worms are arranged in the flow-through tube which force the gas onto a circular path (orbit) along the inner periphery of the tubes and in this manner separate the particles on the inner wall of the tubes.

One fluid separator in the form of an oil separator or oil spray separator is known from DE 101 27 820 A1. There, a tubular separator is used which has a diameter of more than 5 cm. Accordingly only a coarse separation of the oil from blow-by gases is effected in this spiral flow path. For this reason a further fine separation device follows this separation device.

Further known fluid separators in the form of tubular separators, as for example are described in the patent applications of the same applicant with the file number DE 102004011176.6 and DE 102004011177.4 as well as corresponding international applications filed on the same day as the present application by the same applicant, which claim the priority of these applications, consist of a base body through which flow-through tubes pass, and for each

individual flow-through tube, of a worm-like segment (spiral insert) placed into the respective flow-through tube.

At the same time, as is usual in the technical language, a worm is defined as a helical or also spiral thread led around a middle axis.

The length of the introduced segments at the same time is directed to the conditions of installation and the demanded separation performance and is often a multiple of the pitch of the segment. A one-piece manufacture of such long segments together with the flow-through tubes however comes face to face with great difficulties with regard to manufacturing technology and is even not possible for certain materials and manufacturing methods.

The base body, the flow-through tubes and the worm-like segments of the individual flow-through tubes are therefore separate or separately manufactured parts. This necessitates the individual parts having to be securely connected to one another. Thus in particular the individual worm-like segments need to be secured in the respective flow-through tubes.

Since several small fluid separator elements in a base body have a better efficiency than one large fluid separator element, and since several small fluid separator elements may be better adapted to the respective task (e.g. to an oil quantity to be separated in a motor or to a water quantity to be separated in a fuel cell, to the conditions of installation and likewise), the trend towards a larger number of individual fluid separator elements per base body or per fluid separation device continues.

It is the object of the present invention to provide a fluid separation device with which the number of parts is significantly reduced, wherein the fluid separation device despite this may be manufactured in an economic manner and with a low failure rate.

This is achieved by a fluid separation device according to claim 1 as well as by a manufacturing method according to claim 14. Advantageous designs are described in the respective dependent claims. The uses of such fluid separation devices are specified in the claims 16 and 17.

The fluid separation element according to the invention (and thus also the fluid separation device) belongs to the class of tubular separators since it is provided with a flow-through tube with an inlet and with an outlet for the gas.

The basis of the fluid separation device according to the invention as a result is a fluid separator element with a flow-through tube and a worm-like segment arranged therein.

According to the invention, it is characterised in that the flow-through tube and the worm-like segment have been manufactured as one piece as a common fluid separator element.

These fluid separator elements are integrated into a plate-like base body, wherein their flow-through direction is advantageously essentially perpendicular to the plane of the plate of the base carrier. The individual fluid separator elements as well as the associated base carrier (base body) are designed as one piece as a common component.

The individual segments at the same time have a length (in the axial direction) of less than 0.5 pitches. The flow-through itself however including an inlet and/or outlet region may have a larger length. The pitch as the same time is defined as the length of the worm-like segment in the axial direction of the passage which the segment were to have with a complete revolution of the thread surfaces (= screw surfaces) by 360°.

Since the worm-like segments have a length of maximally up to half a pitch, each base carrier may be manufactured as one piece as a cast part, in particular as a die-cast or an injection moulded part. By way of this it becomes possible to manufacture the flow-through tube and the worm-like segment of a fluid separation element, or all fluid separation elements and their base carriers in the same manufacturing cycle. Thus many flow-through tubes may be manufactured in a passage with an integrated worm-like segment in the same subject. Very small inner diameters for the flow-through tubes, for example 3 mm are possible on account of this.

In one advantageous embodiment, at least two base carriers manufactured in such a manner are arranged bordering one another such that the individual fluid separator elements (or their flow-through tubes) of the individual base carriers are allocated to one another such that in each case one fluid separator element or flow-through tube of a base carrier, with the associated fluid separator element or flow-through tube of the at least one adjacent base carrier, forms a common flow path for the gas, said flow path reaching through all base carriers arranged on one another.

It is particularly advantageous when at the same time the rotational direction (clockwise or anticlockwise) of the gas which is produced by the worm-like segments changes between two base carriers arranged adjacent to one another: if a first segment has an anti-clockwise rotational direction of the thread surfaces of the worm-like segment in the gas flow direction, then the subsequently arranged worm-like segment has a clockwise rotational direction of the thread surfaces or of the associated flow path or paths.

It has now been surprisingly ascertained that with such a serial arrangement (so that a common flow path for the gas is formed from the flow-through tubes and worm-like segments of

individual fluid separator elements of base carriers arranged one after the other) of at least two such fluid separator segments, wherein the individual segments advantageously maximally have a length corresponding to 0.5 times their pitch, the separation may be carried out in an extremely efficient manner, also and indeed when the rotational direction of successive segments is in opposite directions to one another, so that the gas must be deflected from the one rotational direction to the other rotational direction within the serially connected flow-through tubes of two fluid separator elements.

By way of these worm-like segments connected serially with an opposite rotational direction, impingement surfaces arise on which the fluid or the fluid spray is separated in an excellent manner. The thread surfaces of the worm-like segments may at the same time be arranged such that the thread surfaces of the subsequent segment project into the flow path formed by a thread surface of the preceding segment. At the same time it is particularly advantageous if the thread surface of the first segment projects roughly up to the middle* into the flow path formed by the thread surface of the second adjacent segment.

However, base carriers with segments which are aligned in the same direction may be arranged bordering one another.

The outlet-side edge of a first segment and the inlet-side edge of the subsequently arranged second segment, said edges being arranged adjacent one another, may advantageously be arranged rotated (twisted) relative to one another about the central axis of the common flow path by an angle, in particular by an angle between 45° and 135°, particularly preferred by about 90°.

Thus with the first-mentioned fluid separation device, the rotational direction of the segments (spirals) changes in each case between adjacent base carriers. Thus for the complete separator unit only two base carriers reversed in rotational direction need to be serially assembled, in order to achieve a high separating performance for the gas flow on account of the change in rotational direction or the impingement surfaces which they entail respectively. Irrespective of the number of base carriers arranged one after the other, thus the whole fluid separation device may be constructed merely from two different types of base carrier. With lower demands with respect to the separation performance, or for the application as a coarse separator, one may also use only one plate-like base carrier.

Advantageously each of the separator elements has at least two flights or flow paths. For this, the flow-through tube is subdivided perpendicularly to the longitudinal axis in a manner such that two or more flights which are separate form one another arise. For this a thread surface

of one segment is sufficient. However also the arrangement of several interwoven thread surfaces is possible.

In a further advantageous embodiment at least one of the flow paths has a smallest cross section between 1 mm^2 and 800 mm^2. It is particularly advantageous if such a flow path has a smallest cross section of $\geq 2\ mm^2$ and/or $\leq 400\ mm^2$, preferably $\geq 4\ mm^2$ and/or $\leq 200\ mm^2$.

Advantageously at least one flow path runs at an angle of about 45° to the axial direction. Advantageously at least two of the successive, worm-like segments of fluid separation devices adjacent to one another are arranged directly connecting to one another or with a positive-fit in the axial direction. The segments may however not be arranged over the whole flow-through tube, but at the beginning, in the middle and at the end of a flow-through tube. In the latter case thus also adjacent segments may be arranged somewhat separated from one another in the axial direction.

The flow may enter into the flow-through tube axially or under certain circumstances also tangentially, and may exit this axially and/or tangentially. An entry and exit at a limited angle with respect to the axial direction and/or the tangential direction is possible. However an axial entry and/or exit of the gases is technically advantageous.

Advantageously the inlet of the flow-through tube is arranged in a manner such that the flow-through tube has an inflow at an angle ≤ 45° to the axial direction or at an angle of ≤ 45° to the tangent on the periphery of the flow-through tube. Advantageously the outlet is arranged in a manner such that the gas flows out of the flow tube at an angle ≤ 45° to the axial direction or at an angle ≤ 45° to the tangent on the periphery of the flow-through tube.

Flow-through tubes and/or flow paths arranged next to one another advantageously have the same diameter and thus the same pressure drop over the lengths of the flow-through tube or the flow path.

Advantageously at least one of the flow-through tubes at its thinnest location has an inner diameter ≤ 30 mm, preferably ≤ 25mm, preferably ≤ 12 mm, preferably ≤ 7 mm. Advantageously a flow-through tube and/or a flow tube formed of several serially arranged flow-through tubes, at its thinnest location or on its entire length has an inner diameter of ≥ 1 mm, preferably ≥ 2mm and preferably ≤ 10 mm.

In a further advantageous embodiment the wall thickness of the thread surface of a segment at its thinnest location or on its entire length is more than 1/20 and/or less than half,

advantageously more than 1/10 and/or less than 1/3 of the diameter of a flow-through tube or flow tube.

In a further advantageous embodiment, the pitch of a segment is ≥ 1/8-fold and/or ≤ 10-fold, advantageously ≥ 1/4- and or ≤ 5-fold, advantageously ≥ 1/2 and/or ≤ twice, the diameter of the associated flow-through tube.

The flow-through tubes may advantageously further be conically widened at the beginning and/or at their end, in order to minimise the pressure loss in the flow-through tube. A widening at the end of a flow-through tube furthermore reduces the gas speed so that at possible edges of the thread surfaces at the end of the last segment, no droplet shear and thus atomisation of the already separated fluid is effected.

One or more successive segments and/or the common flow tube formed over the whole length by way of the arrangement may be reduced in sections or over the whole length with respect to the diameter.

In another embodiment a segment of a fluid separation element (or also several or all serially arranged segments of the fluid separator elements associated with one another, of the serially arranged base bodies) in the axial direction, at the beginning and/or at the end has a thickened axial core of the segment or segments or end segments, said core being thickened in a conical manner towards the beginning or end.

In a further embodiment for at least one of the segments or for several or all serially arranged segments of a common flow tube, the distance between the core of the worm-like segment or the worm-like segments and the wall of the flow tube reduces in the axial direction.

In a further advantageous embodiment for one segment or for several or all serially arranged segments of a common flow tube, the radius of the core of the worm-like segment or of the worm-like segments and/or the diameter of the flow-through tube or of the common flow tube reduces in the axial direction.

In a further embodiment for at least one segment or for several or all serially arranged segments of a common flow tube, the pitch within the segment or the segments at least in sections increase or reduces in the axial direction.

In a further advantageous embodiment also at least the flow-through tube of a fluid separator element, or a common flow tube of fluid separator elements arranged serially, as an

inlet region, may comprise a starting section and/or as an outlet region an end section, in which no worm-like segments are arranged.

Such a starting or end section advantageously has a length of greater than double the diameter of the flow-through tube.

The individual base carriers may advantageously be designed as a flat plate (for example in a cylinder-shaped manner). Basically their shape is deduced from the installation situation with its spatial conditions and may be selected in an infinite manner. The height of the plate (in the direction of the axial direction of the flow-through tubes of the individual fluid separator elements) is then advantageously less than about 1.5 times, preferably less that once and very particularly preferred less than 0.5 times the pitch of the worm-like segments of the individual fluid separator segments.

If several base carriers are arranged serially then it is advantageous if this is effected in a positive fit manner to one another. For this, the base carriers may be connected to one another, for example glued, screwed and/or locked. In order to fix the relative position of the base carriers to one another, it is advantageous to design the base carriers in a manner such that they comprise means with which the relative position of two base carriers arranged adjacent to one another is defined relative to one another. This may for example be effected by way of tongue and groove elements and likewise, which are provided of sides of successive base carriers, said sides facing one another. It is also possible to provide the base carrier with a bore which goes through all base carriers, into which an arbor may be introduced. The bore and the arbor may for example likewise have tongues and grooves which then determine the position of the individual base carriers.

The base carriers for their part may be fastened via rails in the component surrounding them, for example in a water separator in a fuel cell or a valve cover for a combustion engine, wherein the size and arrangement of the rails is selected such that in each case one rail receives a base carrier with one of its edges. In this manner, by way of the arrangement of the individual rails, the number of the base carriers as well as their relative position may likewise be fixed. Such a rail system further contributes to the modularity of the present invention.

In order to lead away the fluid separated at the wall of the serially connected flow-through tubes, their wall, advantageously in the axial direction may comprise grooves and channels. It is also possible in the axial direction to attach webs for leading the separated fluid to the outlet of the flow-through tube. The thread surfaces too may comprise slots and/or channels which lead away the separated fluid. It is particularly favourable if the grooves run in the outer edges of the thread surfaces.

The fluid separation device according to the invention has a series of advantages:

- the number of the required individual parts for the fluid separation device (worm-like segments, flow-through tubes or fluid separator elements) may be significantly reduced.

- this leads to considerable cost savings and simplification of the assembly.

- furthermore the securing of the individual elements is done away with.

- the separation intensity is maximised in comparison to other cyclone-like separators. This particularly results when a multitude of fluid separator channels (formed by at least one or by a plurality of fluid separator elements arranged serially and allocated to one another) operate in a parallel manner to one another.

- thus compact, integrated fluid separation device with a low pressure loss, a high capacity and stable gas flows is possible.

- the number of the individual flow-through tubes or common gas flow paths may be selected depending on e.g. the conditions within a fuel cell, where more water occurs on the cathode side than on the anode side, on the blow-by characteristics of a motor, on the maximal pressure drop and/or the maximal permissible fluid transfer.

If the flow-through tubes have a diameter ≤ 30 mm then these may also be installed into flat valve bonnets (valve covers). With fuel cells there exists significantly more possibilities of incorporation so that not such extreme limitations with respect to the dimensioning are required.

The core (heart) of the worm-like segment may furthermore be removed in the inlet and/or in the outlet region, in particular with the (seen in the gas flow direction) first and/or last flow-through tube of a flow path. A further reduction of the flow pressure losses is effected by way of this. A cone-like removal of the core is particularly favourable so that a free flow region is present in the middle axis of the segment or the serially connected segments.

A few examples of the present invention are described in the following. Here, as in the following, the same or similar reference numerals are used for the same or similar elements so that the description to some extent is not repeated.

There are shown in:

Figure 1	a cylinder head cover with installed oil separators;
Figure 2	a section through a cylinder head cover;
Figure 3	an oil separator with 2 base carriers;
Figure 4	two base carriers together with integrated fluid separator elements for forming an oil separation device according to the invention;
Figures 5 and 6	the plan view in the axial direction of the base carrier according to Fig. 4;
Figure 7	various shapes of worm-like segments;
Figure 8	an oil separation device with two base carriers in a perspective view and a plan view as well as two worm-like segments of two oil separator elements, said segments bordering one another and arranged serially in a common flow tube; and
Figure 9	a electrochemical cell with a fluid separation device.

Figure 1 shows a cylinder head cover 1 which may be attached onto a cylinder head of a combustion engine. This cylinder head cover 1 comprises a cavity 2 which has an inlet 3 and an outlet 4 for gases. Now the blow-by gases via the inlet 3 are blown out of the crank case of the combustion engine into the cavity 2 and leave this cavity 2 via the outlet 4. The crank case gases are freed from entrained oil or oil spray within this cavity 2. This oil spray or the separated oil is collected in a siphon 6 and led back continuously into the oil sump or is also led back in portions.

Impingement plates 5 are arranged in the cavity 2 of the cylinder head cover 1 directly behind the inlet 3. These impingement plates have the effect that a coarse separation of oil droplets is already effected on them. The impingement plates 5 for this are arranged offset such that a labyrinth-like path of the gas through the impingement plates results.

A separation device 10 according to the invention is arranged in the gas path behind the oil coarse separator of the impingement plate 5 and this device consists of two individual elements 10a and 10b. Each of the elements 10a and 10b comprises a plate-like base carrier 21a

and 21b respectively, in which in each case at least one separator element 20a, 20b which may be recognised in cross section is arranged. The base carrier 21a and 21b are fastened in rails which are formed in the housing of the cylinder head cover 1. The separator elements 20a and 20b in each case comprise a flow-through tube 22a, 22b in which in each case a worm-like segment 23a and 23b respectively is arranged. The blow-by gases enter into the flow-through tubes 22a and 22b and are set into a rotating movement by way of the worm-like segments 23a and 23b. By way of this the oil or the oil spray is spun out of the gas and is separated on the wall of the flow-through tube 22a and 22b. The oil which is separated in this manner is transported along the wall of the flow-through tube 22a and 22b in the gas direction and subsequently runs into the siphon 6. Within the cylinder head cover the flow-through tubes 22a and 22b at the same time represent the only (single) passage between the inlet and outlet 4 for the blow-by gases.

As is to be recognised in Figure 1, the worm-like segment 23a is installed and fixed in a rotated manner such that the gas is set into a clockwise rotational movement (clockwise direction). The segment 23b arranged after this has a rotational direction in the other direction so that there the rotational direction of the gas is reversed into an anticlockwise rotation (opposite to clockwise direction). In particular, on account of such a reversal of the rotational direction, there results a particularly good separation rate of the separation device 10 represented here. It must be noted that the worm-like segments do not rotate themselves, but are fixed within the flow-through tubes.

Figure 2 shows a corresponding cylinder head cover 1 in a cut-out, wherein here a cavity 2 is likewise arranged in the valve cover 1, and in which a separation device 10 is likewise located. A siphon 6 for collecting the separated oil is likewise arranged after the impingement plates 5 and the separation device 10 in the gas flow direction.

From this figure it is now to be easily recognised how the separation element 10 is constructed of two plate-like base carriers 21a and 21b. The two base carriers 21a and 21b are arranged in rail-like holders 7a, 7a' and 7b, 7b' respectively. Each of the base carriers furthermore comprises three separator elements 20a arranged next to one another transversely to the gas flow direction, for the base carrier 21a and 20b, 20b' and 20b" for the base carrier 21b. The further arrangement of the flow-through tubes 22a' and 22b, 22b' and 22b" as well as the correspondingly marked worm-like segments 23a as well as 23b, 23b' and 23b" corresponds to that of Figure 1. Here too a reversal of the rotational direction of the gas flow between the base carriers 21a and 21b is effected.

The worm-like elements, explained here with the example of the worm-like element 23a, have an inlet 26a of the flow-through tube 22a, an inlet-side edge 29a and as explained with the

example of the flow tube 22b, an outlet-side edge 30b on an outlet 27b. The conditions in the other flow tubes correspond to these and therefore are not described separately.

In this figure it may be particularly well recognised that the outlet-side edge 30a of the separator element 20a and the inlet-side edge 29b of the separator element 20b are offset by 90° to one another, so that the inlet-side edge 29b projects into the flow path of the gas of the separator element 20a. By way of this, a particularly effective separation of oil and oil spray may be effected.

Figure 3 then shows two base carriers 21a and 21b of a separator device 10 as is for example used in Figure 2. Here as in all previous and subsequent figures, similar or corresponding elements are indicated with similar or corresponding reference numerals (only modified by the additions such as a, b, ', ",'"). Here it is to be recognised that the base carrier 21a and 21b are plate-like and the flow-through tubes 22a, 22a', 22a''' etc. project from the respective base carriers 21a and 21b respectively. The flow-through tubes contain worm-like segments, e.g. 23b, 23b', 23b", ... With regard to the invention it is particularly advantageous that the respective base carrier 21a and 21b with the through flow tubes 22a, 22a', ... and 22b, 22b', ... arranged in it respectively, and the worm-like segments arranged in the respective flow-through tubes may be manufactured as one piece for each base carrier 21a and 21b respectively. This then may only be accomplished in an economical way and manner for example by way of injection moulding method or die casting method if the worm-like segments have a length which is smaller or equal to half a pitch of the respective worm-like element. Longer worm-like segments with regard to manufacturing technology would only be capable of being manufactured at an extremely great expense.

Figure 4 shows an oil separation device 10 which comprises two, in each case flat, cylinder-shaped base carriers 21a and 21b. The two base carriers 21a, 21b for an improved representation are sketched at a distance to one another in the direction of the axis of symmetry of the cylinder. In this oil separation device 10 according to the invention, the two plate-like base carriers 21a, 21b however are arranged directly bordering one another such that they form a common cylinder with a cylinder height which corresponds to the thickness of the two plate-like base carriers in the direction of the axis of symmetry. Four oil separator elements (20a, ..., 20b, ...) with their flow-through tubes 22a, ..., 22b, ... together with the associated worm-like segments 23a, ..., 23b, ... are integrated into each base carrier 21a, 21b. The four oil separator elements 20a, ..., 20b, ... are arranged on a circle about the cylinder axis in the plane perpendicular to the cylinder axis. The worm-like segments 23a, ..., 23b, ... in each case have a length corresponding to half the pitch. Each base carrier 21a, 21b, its associated flow-through tubes 22a, ... and its associated worm-like segments 23a, ... is in each case manufactured as one piece as a common die-cast part. Both base carriers 21a, 21b by way of this may be integrated into a single oil

separation device 10 in that the two cylinders 21a, 21b are arranged directly bordering one another in a manner such that the two cylinder axes coincide. At the same time then two flow-through tubes 22a and 22b or 22a' and 22b', in each of one of the first base carrier 21a and one of the second base carrier 21b, form a common flow path for the gas. Thus the flow-through tubes 22a and 22b together with their worm-like segments 23a and 23b from a common flow path. Since then all worm-like segments 23a, 23a', ... of the one base carrier 21a have an anticlockwise rotational direction and since all worm-like segments 23b of the other base carrier 21b have clockwise rotational direction, and since the worm like segments 23a, 23b and 23a', 23b', ... (of the different base carriers 21 and 21b) which are allocated to one another and which form a common flow path are twisted to one another by 90° with respect to the central axis of the respective flow path 22, in the oil separation device 10 for each common flow path at the height of the transition from one into the other base carrier, in each case a impingement surface is formed which improves the separation of the oil.

In order to achieve an exactly fitting alignment of the two base carriers 21a, 21b in the oil separation device 10, the base carrier 21b on the surface which borders the other base carrier 21a is provided with a bulge 16 in the form of a cylindrical projection. This projection 16 engages with a positive fit into a corresponding indentation (not shown) in the form of a cylinder-shaped recess into the base body 21a. The bulge 16 and the indentation serve for preventing a mutual rotation of the two base carriers 21a, 21b about the common cylinder axis in the completed assembled condition. The bulge 16 and the indentation thus serve to ensure the common flow paths through the oil separation device 10 and to fix the relative arrangement of the individual worm-like segments 23a, 23b of each individual common flow path.

In place of only one bulge 16 and associated indentation, embodiment examples with a plurality of lock-in possibilities are possible. These, e.g. with a circular arrangement of an even number of worm-like segments with alternately arranged clockwise and counter clockwise rotating worm-like segments, offer the possibility of using the same basic modules for the manufacture of a fluid separator with a flow direction which is the same or counter to one another, in the serially arranged worm-like segments.

If for example in Figure 4 in each case two separator elements 20a, 20a' which lie opposite one another are provided with worm-like segments 23a, 23a' which are in the same direction, for example clockwise, and the remaining separator elements 20a" and 20a'" which lie opposite one another are provided with worm-like segments 23a" and 23a'" which both are twisted anti-clockwise, then by way of serial arranging two such base carriers 21a one may effect any change in the rotational direction. This is because two base carriers may be arranged serially such that between them no change in the rotational direction in the respective separator elements is effected, or also by way of installing one of the base carriers offset by 90° such that a change

in rotational direction between the serially arranged worm-like segments in the two base carriers is effected. The modularity may then be realised in a particularly simple manner if rails are arranged at the location of installation for serially arranged base carriers, in order to accommodate the carriers. By way of different orientation of the base carriers on insertion or introduction into the corresponding rails one may then infinitely select which type of rotational direction and thus change in rotational direction between individual base carriers is to be effected.

Apart from an arrangement of successive worm-like segments 23 which alternate with respect to the rotational direction as in the introduced case, one may also arrange equally directed worm-like segments one after the other, wherein in both cases these are twisted relative to one another from base body to base body in each case by 90° about the central axis of the common gas flow path 22. Bores 15a, 15b are incorporated centrally into the cylinder-shaped base carrier 21a, 21b for aligning the cylinder axes of the base carrier. Guide pins may be introduced into these bores 15a, 15b in an exactly fitting manner.

The guide bores 15a, 15b may at the same time in each base body 9 be provided each with a fin (spring) in the direction of the cylinder axis. The corresponding guide pin may then have a notch or groove corresponding to this fin so that by way of the guide pin one may achieve the desired positioning of the two base carriers 21a, 21b relative to one another with regard to the rotational position about the common cylinder axis. A tongue and groove may also be arranged on the respective other component in order to achieve the desired rotational securement.

In the shown base carriers 21a, 21b, the axial directions of the individual oil separator segments 20 or flow-through tubes 22 are directed parallel to the cylinder axis of the base carrier 21a, 21b. For achieving an inclination of the flow paths for leading away fluid also when the vehicle has been positioned obliquely, the complete oil separation device 10 may be installed tilted by an angle $\alpha > 0$ to the horizontal (angle α = angle between the central cylinder axis of the oil separation device and the horizontal). Alternatively to this, the individual oil separator elements 20 may be integrated into the base carrier 21 in a manner such that the axial directions of the oil separator elements 20 form an angle > 0° to the cylinder axis of the base carrier 21.

Figures 5 and 6 show views of the two sides of the base carrier 21b represented in Figure 4.

Figure 7 in part pictures 7A, 7B, and 7C in each case show worm-like segments 23 which all rotate clockwise (clockwise direction). One may recognise that these worm-like segments 23 comprise edges 30 on the inlet side and edges 29 on the outlet side. The worm-like segments 23 at the same time form two thread surfaces or thread surfaces 28a and 28b and divide the flow

path of the gas into two flights. In the part figures A, B, C various variants are represented, wherein the inlet-side as well as the outlet-side bevelled edge 30 and 29 respectively are present in Figure 7A. The inlet-side edge in Figure 7B is designed differently, whilst in Figure 7C the outlet-side edge 29 and the inlet-side edge 30 have a different shape. Figure 7C furthermore in contrast to the Figures 7A and 7B has a stabilising core.

Figure 8 sketches a view of two worm-like segments 23a and 23b as may be applied in a common flow path 25 by way of two base carriers of an oil separation device which are arranged one after the other. Both worm-like segments 23a, 23b have a length corresponding to 0.5 times their pitch as well as the same rotational direction (clockwise).

Figure 8 furthermore shows a cylinder-shaped separation device 10 in a lateral view in which two base carriers are integrated with a positive fit such that they are fixed to one another.

The figure furthermore sketches a plan view of the separation device 10 with a central guide bore 15 and at a different distance to this central guide bore, a plurality of oil separator elements 20a, 20b, ...

Figure 9 shows a PEM fuel cell 40 which on the anode side is supplied through a conduit 43 with fuel, for example molecular hydrogen H_2. The cathode-side reaction products are led away via a conduit 42. The cathode-side reaction product is essentially H_2O. With fuel cells, a humidification of the supply of fuel on the anode side through the conduit 43 as well as the cathode-side supply of fuel (O_2, air or likewise) which here is not shown, is required, so that the membrane does not dry out and lose its function. For this, and shown by way of the example of the conduit 43, this conduit runs through a device for gas humidification. In this device, the anode-side fuel is humidified.

On the other hand on the cathode side (pure) water is produced as a reaction product so that an enormous excess of water is present in the conduit 42 at the exit side. This water which is led away with the reaction gases via the conduit 42 may be removed from this waste gas. For this then according to the invention a water separator device 10 is arranged in the conduit 42. Three base carriers 21a, 21b, 21c which are drawn by way of example here contain water separator elements 20c, 20c' and 20c''' which are likewise drawn only in a sketched manner are located in this separation device. The separator elements in the base carriers 21a and 21b and which are mounted upstream on the flow path of the gas are likewise not shown here, but together with the separator elements 20c, 20c', 20c'' in each case form common flow paths. With such a separator the water droplets which condense indirectly after leaving the fuel cell in the conduit 42 may be separated.

Until now the water produced on the cathode side escapes into the outer air and expensively prepared water must be used in order to humidify the supplied reaction gases.

The pure water which in this manner is removed from the reaction gas may now however be led to the humidification device 41 via a water return conduit 44 so that no water needs to be supplied externally to the complete system in order to maintain the circulation of water.